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Hydrocephalus in encephalocele

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Abstract. – OBJECTIVE: Encephalocele is a rare congenital neural tube defect (NTD) characterized by herniation of intracranial contents through a defect in the skull. In our study, encephalocele was diagnosed in our clinic and its association with hydrocephalus was evaluated. The effect of this association on the prognosis was discussed.

PATIENTS AND METHODS: Patients who underwent surgery and follow-up with the diagnosis of encephalocele in the neurosurgery clinic of our hospital in an 8-year period from 2013 to 2021 were retrospectively examined.

RESULTS: Patient records were obtained from the case notes of patients who underwent excision and repair for encephalocele. Of the 78 patients included in the study, 88.4% underwent surgery in the neonatal period. Moreover, 47% of the patients are male, and 31% are female. Encephalocele was present in 62.8% of patients and meningocele in 37.2%. Furthermore, 82.1% of encephalocele sacs were located in the occipital region. Chiari type 3 malformation was present in 57.6% of patients. Hydrocephalus developed in 56.4% of patients. There was an additional syndrome in 10.3% of the cases. The most common additional syndromes were corpus callosum dysgenesis with 39.7% and colpocephaly with 29.5%. The additional disease was present in 43.6% of patients. Preoperative and postoperative examination findings of more than half of patients were normal, but 33.3% were apathetic. Furthermore, 67.9% of patients, who underwent complete repair, survived, and 32.1% died. Hydrocephalus was present in 73.5% of patients with encephalocele ($p<0.05$). Hydrocephalus developed in 77.8% of patients with Chiari type 3 malformation ($p<0.05$). Hydrocephalus was found in 88.0% of patients with Ex ($p<0.05$).

CONCLUSIONS: Encephalocele, which is a subgroup of NTD, differs clinically by its location and accompanying additional anomalies. In encephaloceles, the risk of morbidity and mortality can only be reduced with the multidisciplinary approach. Hydrocephalus and Chiari type 3 malformation are common in patients with encephalocele. These associations adversely affect the prognosis of the disease. Further research should be conducted on the evaluation of risk factors of NTD and methods of prevention from NTD. In this regard, we recommend that the training be repeated at certain intervals and that people's awareness should be raised.

Key Words:
Chiari type 3 malformation, Encephalocele, Hydrocephalus, Meningocele, Neural tube defect.

Introduction

Encephalocele is a congenital neural tube defect (NTD) characterized by herniation of intracranial contents (meninges, brain, and part of the ventricles) through a defect in the skull. Encephalocele occurs because the cranial part of the neural tube that develops in the first few weeks of fetal life does not close[1].

Inadequate separation of the surface ectoderm from the neural ectoderm in the fourth week of pregnancy is the main mechanism by which encephaloceles occur. Failure to separate these two layers causes an abnormal skull opening. Herniation of intracranial contents causes either a meningocele (which contains only the meninges) or encephalomeningocele (which involves both the brain and surrounding meninges). Classification of encephaloceles depends on the lesion site[2].

Encephaloceles are the rarest form of NTD. Although it can be located in the frontonasal and nasoethmoidal regions, it is most commonly encountered in the occipital (75%) region[3]. Its incidence is 1-5/10,000 live births.

One-third of patients die, and 76% of deaths occur within the first day after birth. Half of the patients who survive after the first day have some degree of neurodevelopmental delay. Occipital encephaloceles may be accompanied by other congenital abnormalities, including the central nervous system. These associated abnormalities are essential for prognosis[4].

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Most infants with encephalocele who survive have cognitive deficits. Hydrocephalus, spasticity, and seizures are also common in these children. About half of these children have chromosomal abnormalities. Up to 65% of occipital meningoceles and encephaloceles are associated with hydrocephalus[5].

In our study, 78 patients who underwent surgery with the diagnosis of encephalocele in our clinic and the association of these patients with hydrocephalus were evaluated. This study aimed to investigate the effect of this association on prognosis.

Patients and Methods

This study is a retrospective review performed in the Neurosurgery Department of our hospital for an 8-year period from 2013 to 2021. Data were obtained from the records of patients who underwent encephalocele excision and repair. Clinical data of 78 patients were extracted. This study was conducted in accordance with the tenets of the Declaration of Helsinki 1964. The study was approved by the Van Yüzüncü Yıl University Clinical Research Ethics Committee Presidency of (No: 22.06.2021-08). Signed statements of informed consent to participation and publication were obtained from participants before the study.

Statistical Analysis

Data entry and analysis of the research were conducted with the SPSS 15.0 statistical program (SPSS Inc., Chicago, IL, USA) licensed from Van Yüzüncü Yıl Üniversitesi. Chi-square and Fisher's precision test were used to compare categorical variables. A p-value <0.05 was considered significant.

Results

Of the patients included in the study, 88.4% underwent surgery in the neonatal period. Moreover, 47% of patients were male, and 31% were female. Encephalocele was present in 62.8% of patients, and meningocele in 37.2%. Moreover, 82.1% of the encephalocele sacs were in the occipital region. Chiari type 3 malformation was present in 57.6% of patients. Hydrocephalus developed in 56.4% of patients. There was an additional syndrome in 10.3% of patients. The most common additional syndrome was corpus callosum dysgenesis with 39.7% and colpocephaly with 29.5%. The additional disease was present in 43.6% of patients. Preoperative and postoperative examinations of more than half of the cases were normal, but 33.3% were apathetic. Furthermore, 67.9% of patients who underwent complete repair of the pouch survived, and 32.1% died (Table I).

The development of hydrocephalus according to some variables is examined in Table II. There was no significant difference between the development of hydrocephalus according to sex and region of the encephalocele sac (p>0.05). Hydrocephalus developed in 77.8% of cases with Chiari type 3 malformation (p<0.05). Hydrocephalus developed in 75.8% of cases with sac size ≥ 10 cm (p<0.05). There was a significant difference between the presence of additional syndrome and additional disease and the presence of hydrocephalus. Hydrocephalus was found in 73.1% of patients with additional syndrome and 73.5% of patients with the additional disease (p<0.05). There is a significant difference between the preoperative and postoperative examination and the presence of hydrocephalus. Hydrocephalus developed in 80% and 82.2% of the patients whose preoperative and postoperative examinations showed apathy and paraplegia, respectively (p<0.05). There was a significant difference between the encephalocele type and the development of hydrocephalus. Hydrocephalus was present in 73.5% of patients with encephalocele (p<0.05), and 88.0% of patients with Ex (p<0.05) (Table II).

Discussion

One of the important reasons that can affect the growth, development, and sociological structure of societies is congenital (congenital) defects. We can group the causes of these congenital defects as structural, functional, metabolic, behavioral, and hereditary[6]. NTD is one of the most common and most severe congenital malformations with clinical features. It occurs as a result of neural plate failure to form the neural tube during embryogenesis. The prevalence of NTD worldwide is known as 0.5-2/1000 pregnancies, 1/1000 pregnancies in Europe, and 0.5-1/1000 pregnancies in the USA[7]. According to the results of studies conducted in various centers in Turkey, the frequency of NTD varies between 3 and 5.8 per 1000 pregnancies[8]. The pathophysiology of NTD is a complex mul-

Table I. Frequency distribution of patients with encephalocele.

	N (%)
Sex	
Male	47 (60.3)
Female	31 (39.7)
Total	78 (100)
Area	
Occipital	64 (82.1)
Parietal	2 (2.6)
Frontonasal	4 (5.1)
Occiptocervical	4 (5.1)
Frontotemporal	1 (1.3)
Occipital, lumbar	3 (3.8)
Total	78 (100)
Chiari	
No	33 (42.3)
Chiari type 3	45 (57.6)
Total	78 (100)
Additional syndrome	
No	70 (89.7)
Yes	8 (10.3)
Total	78 (100)
Additional syndrome	
Corpus callosum dysgenesis	31 (39.7)
Colpocephaly	23 (29.5)
Cerebral atrophy	5 (6.4)
Dandy-Walker malformation	5 (6.4)
Arachnoid cyst	4 (5.1)
Vermian agenesis	3 (3.8)
Hydranencephaly	3 (3.8)
Corpus callosum agenesis	2 (2.6)
Sringohidromiyeli	1 (1.3)
Cavum septum pellucidum et vergae	1 (1.3)
Dolichocephaly	1 (1.3)
Lissencephaly	1 (1.3)
Additional disease	
No	44 (56.4)
Yes	34 (43.6)
Total	78 (100)
Preoperative examination	
Normal	48 (61.5)
Apathetic	28 (35.9)
Paraplegic	2 (2.6)
Total	78 (100)
Postoperative examination	
Normal	50 (64.1)
Apathetic	26 (33.3)
Paraplegic	2 (2.6)
Total	78 (100)
Anomaly type	
Encephalocele	49 (62.8)
Meningocele	29 (37.2)
Total	78 (100)
Hydrocephalus	
No	34 (43.6)
Yes	44 (56.4)
Total	78 (100)
Patient status	
Ex	25 (32.1)
Live	53 (67.9)
Total	78 (100)

tifactorial disease involving both genetic and environmental factors. There are many types of NTD that differ from each other.

Encephalocele is a congenital malformation that develops as a result of herniation of a part of the dura or central nervous system tissue out of the midline fusion defects of the cranial bones[9-11]. The frequency of encephalocele is reported as approximately 1-5/10000 live births[11-13].

It is thought that encephaloceles are a problem due to mesenchymal insufficiency that develops at 8-12 weeks[10,14]. Along with encephalocele, migration anomalies, such as callosal disorders, heterotopia, and schizencephaly, belonging to the same embryological period can be seen[10,11]. In our patients with encephalocele, association with corpus callosum dysgenesis, colpocephaly, cerebral atrophy, and Dandy-Walker malformation was most frequently observed (Table I).

In the encephalocele sac, there may be only the meninges (meningocele); sometimes, there are cases in which cerebrospinal fluid, nerve tissue, cerebellum, cerebral cortex, and a part of the brain stem are protruding (encephalocele)[15] (Figure 1). The disease can be evaluated in two different types cranial meningocele and encephalocele[10]. The most common type detected in our patients is encephalocele.

While encephalocele is most commonly observed in girls in the west, it is most commonly observed in boys in the east. In our clinic, it was most frequently observed in men. Most encephaloceles are congenital, that is, of primary origin. All our patients had primary encephalocele and were diagnosed congenitally.

Encephaloceles are often isolated anomalies. Encephalocele may be accompanied by syndromes such as cystic dysplastic kidneys, cardiac anomalies, orofacial cleft, and Meckel syndrome[16,17]. The severity of the disease varies according to the associated anomaly.

Encephalocele is noted in the parietal, frontal, temporal, and nasopharyngeal regions, especially in the occipital region. In our patients, it was observed most frequently in the occipital region and mostly associated with Chiari type 3 malformation. Chiari malformation is divided into four types. Chiari malformation is a varying degree of herniation of the posterior fossa structures from the foramen magnum to the upper cervical spinal canal. Chiari type 3 malformation represents the most severe degree of herniation. This rare malformation is difficult to correct surgically and has a poor prognosis. It has been found that morbidity

Table II. Distribution of hydrocephalus by some variables.

	Hydrocephalus			
	Yes n (%)	No n (%)	Total	p
Sex				0.488
Female	28 (59.6)	19 (40.4)	47 (100)	
Male	16 (51.6)	15 (48.4)	31 (100)	
Encephalocele area				0.259
Occipital	28 (59.4)	26 (40.6)	64 (100)	
Others	6 (42.9)	8 (57.1)	14 (100)	
Encephalocele area				0.104
Occipital	38 (59.4)	26 (40.6)	64 (100)	
Parietal	1 (50.0)	1 (50.0)	2 (100.0)	
Frontonasal	0 (0.0)	4 (100.0)	4 (100.0)	
Occipitocervical	2 (50.0)	2 (50.0)	4 (100.0)	
Frontotemporal	0 (0.0)	1 (100.0)	1 (100.0)	
Occipital, lumbar	3 (100.0)	0 (0.0)	3 (100.0)	
Chiari				**0.000**
Yes	35 (77.8)	10 (22.2)	45 (100)	
No	9 (27.3)	24 (72.7)	33 (100)	
Pouch Size				**0.003**
> 10 cm	19 (42.2)	26 (57.8)	45 (100)	
< 10 cm	25 (75.8)	8 (24.2)	33 (100)	
Additional syndrome				
Yes	38 (73.1)	14 (26.9)	52 (100)	**0.000**
No	6 (23.1)	20 (76.9)	26 (100)	
Additional disease				**0.007**
Yes	25 (73.5)	9 (26.5)	34 (100)	
No	19 (43.2)	25 (56.8)	44 (100)	
Preoperative examination				**0.003**
Normal	20 (42.0)	28 (58.0)	48 (100)	
Apathy-paraplegia	24 (80.0)	6 (20)	30 (100)	
Postoperative examination				**0.002**
Normal	21 (42.0)	29 (58.0)	50 (100)	
Apathy-paraplegia	23 (82.2)	5 (17.8)	28 (100)	
Anomaly type				**0.000**
Encephalocele	36 (73.5)	13 (26.5)	49 (100)	
Meningocele	8 (27.6)	21 (72.4)	29 (100)	
Status				**0.000**
Ex	22 (88.0)	3 (12.0)	25 (100)	
Live	22 (41.5)	31 (58.5)	53 (100)	

and mortality rates are increased in patients with Chiari type 3 malformation. The most common location of encephalocele is the cervico-occipital region. Findings are compatible with Matson and Ingraham's classification[18,19] (Figure 2).

The good prognosis criteria in encephalocele are as follows: sac diameter <5 cm, meningocele, dysplastic sac, absence of additional anomalies, and normal ventricles. Poor prognostic criteria are as follows: the sac diameter is >5 cm; the presence of encephalocele and functional neural tissue; the presence of additional anomalies, such as microcephaly and holoprosencephaly; and presence of hydrocephalus[20]. The prognosis of the disease depends on the location, amount, and associated anomalies of the neural tissue in the sac[21]. Moreover, hydrocephalus and microcephaly are the most critical risk factors (Figure 3).

In our study, the majority of our patients had hydrocephalus. It was observed that most hydrocephalus cases were associated with Chiari type 3 malformation and encephalocele. Studies have reported that hydrocephalus is the most common anomaly accompanying encephalocele and one of the most important prognostic criteria[22].

In our study, the frequency of hydrocephalus was found to be significantly higher in patients with a sac size >10 cm and additional disease or additional syndrome. Most infants who died in our study were diagnosed with occipitocervical encephalocele (Chiari type 3 malformation), and it was associated with herniation of posterior

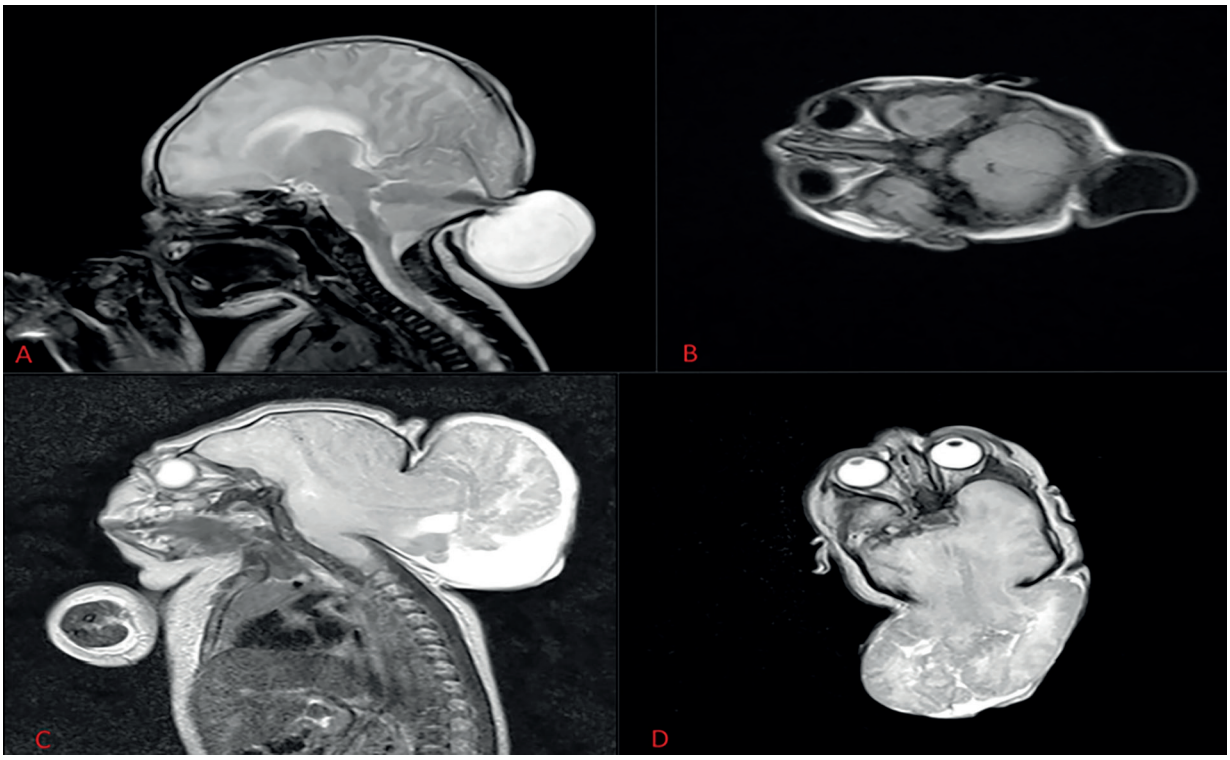


Figure 1. A, B, MRI sagittal and axial view of occipital meningocele. **C, D,** MRI sagittal and axial view of occipital encephalocele with Chiari type 3 malformation.



Figure 2. A, B, E, Preoperative and intraoperative view of occipital encephalocele. **C, D,** MRI sagittal and axial view.

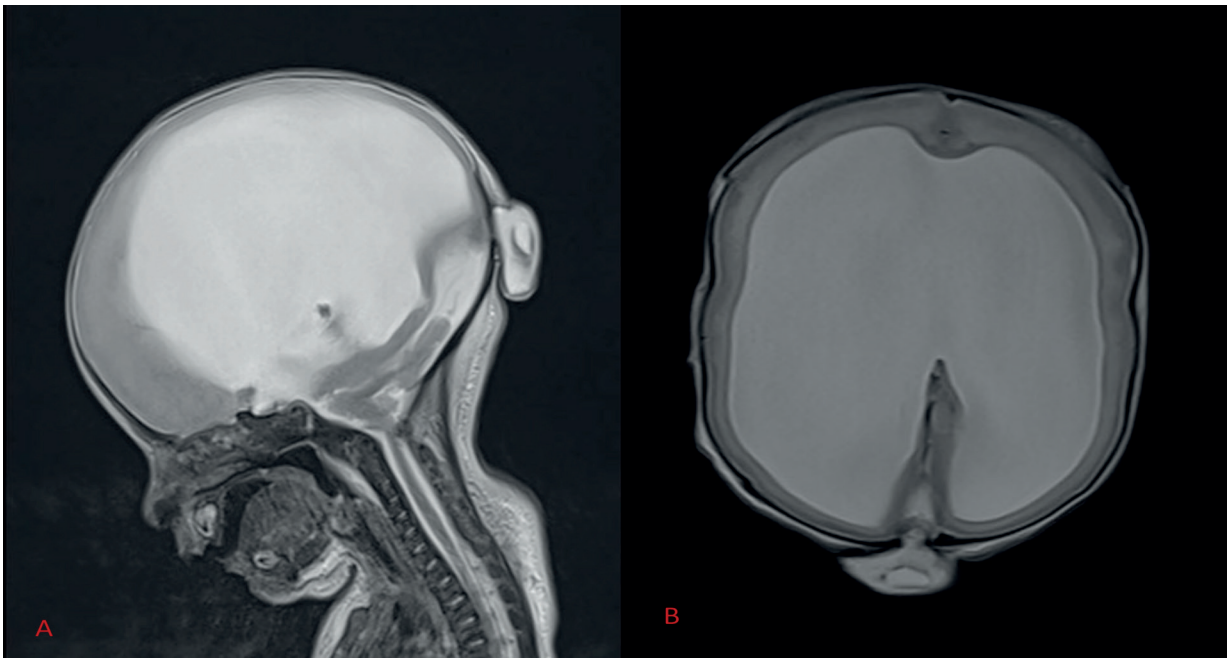


Figure 3. A, B, MRI sagittal and axial view of Hydrocephalus with occipital meningocele.

fossa structures, agenesis of the corpus callosum, and hydrocephalus. It has been observed that our findings are compatible with the literature[22,23]. In another study[23], it was reported that hydrocephalus caused delays in the development of patients with encephalocele. If hydrocephalus, which is one of the poor prognostic criteria, is managed well, better results can be obtained in terms of prognosis.

Conclusions

Encephalocele, which is a subgroup of NTD, differs clinically by its location and accompanying additional anomalies. In encephaloceles, the risk of morbidity and mortality can only be reduced with a multidisciplinary approach. The presence of hydrocephalus in children with encephalocele causes a poor prognosis. Likewise, children with Chiari type 3 malformations had a worse prognosis. Further research should be conducted on the evaluation of risk factors of NTD and methods of prevention from NTD.

Conflict of Interest

All of the authors in this study declare that they have no conflicts of interest in this work.

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Credit Authorship Contribution Statement

MEA: Methodology, Investigation, Writing and original draft, Writing review and editing. IÇ: Methodology, Writing, review and editing. IB: Methodology, Investigation. OA: Investigation.

References

1) Ghritlaharey RK. A Brief Review of Giant Occipital Encephalocele. J Neurosci Rural Pract 2018; 9: 455-456.
2) Marshall AL, Setty P, Hnatiuk M, Pieper DR. Repair of Frontoethmoidal Encephalocele in the Philippines: An Account of 30 Cases Between 2008-2013. World Neurosurg 2017; 103: 19-27.
3) Yucetas SC, Uçler N. A Retrospective Analysis of Neonatal Encephalocele Predisposing Factors and Outcomes. Pediatr Neurosurg 2017; 52: 73-76.
4) Inan C, Cenk Sayin N, Gurkan H, Erzincan SG, Uzun I, Sutcu H, Atli EI, Varol F. A large posterior encephalocele associated with severe ventriculomegaly, cerebellar atrophy and transposition of the great arteries. J Clin Ultrasound 2018; 46: 588-590.

5) Gandhoke GS, Goldschmidt E, Kellogg R, Greene S. Encephalocele development from a congenital meningocele: case report. J Neurosurg Pediatr 2017; 20: 419-422.
6) Moore KL. The developing human: Clinically Oriented Embriyoloji. Persaud TVN (ed), 8th Ed, Saunders Elsevier 2008; pp. 380-416.
7) Wallingford JB, Niswander LA, Shaw GM, Finnell RH. The continuing challenge of understanding, preventing, and treating neural tube defects. Science 2013; 339: 1222002.
8) Tunçbilek E. Türkiye'deki yüksek nöral tüp defekti sıklığı ve önlemek için yapılabilecekler. Çocuk Sağlığı ve Hastalıkları Dergisi 2004; 47.2: 79-84.
9) Caruso PA, Robertson R, Setti B, Grant E. Disorders of brain development. Atla SW (ed, Magnetic Resonance Imaging of the Brain and Spine. Binding 1, Philadelphia: Wolters Kluwert/ Lippincott Williams and Wilkins 2009; pp. 194-271.
10) Partington MD, Petronio JA. Malformations of the cerebral hemispheres. McLone DG (ed), Pediatric Neurosurgery, 4. Printing, Philadelphia: WB Saunders, 2001; pp. 201-208
11) Sanjari R, Mortazavi SA, Amiri RS, Ardestani SH, Amirjamshidi A. Intrasphenoidal Meningo-encephalocele: Report of two rare cases and review of literature. Surg Neurol Int 2013; 4: 5.
12) Singh AK, Upadhyaya DN. Sincipital encephaloceles. J Craniofac Surg 2009; 20 Suppl 2: 1851-1855.
13) Hoving EW. Nasal encephaloceles. Childs Nerv Syst 2000; 16: 702-706.
14) McLone DG. Encephaloceles. Pediatr Neurosurg 2000; 33: 56.
15) Tsai PY, Chang CH, Chang FM. Prenatal diagnosis of the fetal frontal encephalocele by three-dimensional ultrasound. Prenat Diagn 2006; 26: 378-380.
16) Balci S, Tekşen F, Dökmeci F, Cengiz B, Cömert RB, Can B, Ozdamar S. Prenatal diagnosis of Meckel-Gruber syndrome and Dandy-Walker malformation in four consecutive affected siblings, with the fourth one being diagnosed prenatally at 22 weeks of gestation. Turk J Pediatr 2004; 46: 283-288.
17) Shi C, Flores B, Fisher S, Barnett SL. Symptomatic Parietal Intradiploic Encephalocele-A Case Report and Literature Review. J Neurol Surg Rep 2017; 78: e43-e48.
18) Gandhoke GS, Goldschmidt E, Kellogg R, Greene S. Encephalocele development from a congenital meningocele: case report. J Neurosurg Pediatr 2017; 20: 419-422.
19) Baykaner MK, Erşahin Y, Mutluer MS, Özek MM. Pediatrik Nöroşirürji. Türk Nöroşirürji Derneği Yayınları 2014; 15: 368.
20) Singh BK, Maria A, Bandyopadhyay T, Choudhary SK. Clinico-epidemiological profile and outcomes of babies with neural tube defects in a tertiary care center in Northern India. J Matern Fetal Neonatal Med 2021; 13: 1-6.
21) Da Silva SL, Jeelani Y, Dang H, Krieger MD, McComb JG. Risk factors for hydrocephalus and neurological deficit in children born with an encephalocele. J Neurosurg Pediatr 2015; 15: 392-398.
22) Alshamrani A, Habalrih F, Altweijri I, Alsaleh S, Ajlan A. Endoscopic trans-nasal repair of basal encephalocele associated with morning glory syndrome. Br J Neurosurg 2018; 10: 1-3.
23) Nagy MR, Saleh AE. Hydrocephalus associated with occipital encephalocele: surgical management and clinical outcome. Egypt J Neurosurg 2021; 36: 1-7.